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[Aller au sommaire du numéro](#)

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BIG BANG COSMOLOGY, QUANTUM TUNNELING FROM NOTHING, AND CREATION

William E. CARROLL

RÉSUMÉ. — *Certaine recherche récente en cosmologie tente d'expliquer le « Big Bang » lui-même, en s'appuyant sur des aperçus issus de la physique des particules. D'après certains physiciens, c'est l'effet tunnel quantique (quantum tunneling) à partir de rien, concept utilisé pour rendre compte de l'émergence d'un vide de particules subatomiques, qui peut fournir une explication cohérente de la « création » de l'univers à partir de « rien ». Dans l'examen de ce qui semble être les implications théologiques et philosophiques de la nouvelle physique, nous devons pourtant faire attention aux différents sens que peuvent avoir des expressions telles que « rien » et « origine de l'univers », ainsi qu'à la distinction entre création et changement. Il faut aussi se rappeler que la création est un concept métaphysique et théologique qui, comme tel, se trouve au delà du domaine des sciences naturelles.*

SUMMARY. — *Recent work in Big Bang Cosmology employs insights from particle physics in an attempt to explain the Big Bang itself. Some physicists argue that the notion of "quantum tunneling from nothing," which accounts for the emergence of subatomic particles from a vacuum, can provide a coherent explanation of the "creation" of the universe out of "nothing." In examining the apparent theological and philosophical implications of the new physics, we must be careful to understand the different senses of "nothing" and "origin of the universe," as well as the distinction between creation and change. Furthermore, creation is a metaphysical and a theological concept and, as such, is beyond the realm of the natural sciences.*

"I HAD A VISION of a flash of universe appearing from nothing, appearing as a result of the laws of physics. I felt a chill of awe and exhilaration like I have not felt before or since." The vision belongs to Professor Edward Tryon of the Department of

Physics and Astronomy, Hunter College of the City University of New York.¹ In a 1973 issue of *Nature*, he writes: "In my model, I assume that our Universe did indeed appear from nowhere... Contrary to widespread belief, such an event need not have violated any of the conventional laws of physics."² The medieval alchemist who dreamed of changing base metals into gold seems sane in comparison to the contemporary physicist who speaks of getting everything from nothing.

How could such a "flash of universe" have appeared? Quantum electrodynamics affirms that an electron, positron, and photon occasionally "emerge spontaneously" from a "perfect vacuum." And when this spontaneous generation occurs, "the three particles exist for a brief time, and then annihilate each other, leaving no trace behind." Such a spontaneous, temporary emergence of particles from a vacuum is called a "vacuum fluctuation," and is, according to Tryon, "utterly commonplace in quantum field theory." It seems that, as the authors of a 1979 article in the *Scientific American* observe, vacuums are full of all sorts of things called "virtual particles."³

1. As quoted in *The Globe and Mail* (Toronto), 21 January 1985.

2. *Nature*, Vol. 246, 14 December 1973, p. 396.

3. Lewis P. FULCHER, Johann RAFFELSKI, and Abraham KLEIN, "The Decay of the Vacuum," in *Scientific American*, December 1979, Vol. 241, No. 6, pp. 150-159. The authors use the term "virtual particles" to distinguish them from "real particles." To say that vacuums are full of "virtual particles" is a way to express a characteristic feature of the quantum mechanical explanation of "whatever is left in a region of space when it has been emptied of everything that can be removed by experimental means." When all such matter has been removed, the remaining space is not empty; it remains "filled with electromagnetic radiation." See Timothy H. BOYER, "The Classical Vacuum," in *Scientific American*, August 1985, p. 70. Such fluctuating electromagnetic waves constitute an inherent feature of the vacuum, and to say that a vacuum is full of "virtual particles" is to affirm that from these fluctuating waves subatomic particles "pop" into existence.

In "Quantum Gravity" in *Scientific American* of December 1983 (pp. 112-129), Bryce DEWITT observes: "A true vacuum is defined as a state of thermal equilibrium at a temperature of absolute zero. In quantum gravity such a vacuum can exist only if the curvature [of space] is independent of time. When the curvature is time-dependent, particles can appear simultaneously in the vacuum (with the result, of course, that it is no longer a vacuum)... The particles generated by time-varying curvature appear randomly. It is not possible to predict in advance exactly where or when a given particle will be born. One can, however, calculate the statistical distribution of the particles' energy and momentum. Particle production is greatest where the curvature is greatest and changing most rapidly. It was probably very large in the big bang and could have had a major effect on the dynamics of the universe in its earliest moments. It is not implausible that particles created in this way could account for all the matter in the universe! Attempts to calculate big-bang particle production were begun... a decade ago... Although several of the results are suggestive, none is definitive. Moreover, a major question hangs over the effort: What does one choose for the initial quantum state at the instant of the big bang? Here the physicist must play God. None of the proposals made so far seems uniquely compelling." (pp. 118-119)

Even DeWitt's "true vacuum" is quite different from the void, the existence of which, Aristotle and Aquinas would deny. DEWITT observes: "In classical physics flat, empty space-time is called the vacuum. The classical vacuum is featureless. In quantum physics a much more complex entity, with a rich structure, is given the name vacuum. Its structure arises from the existence in it of nonvanishing free fields, that is, fields far from their sources." (p. 115)

Heinz R. PAGELS observes: "According to modern theory, a vacuum is not exactly nothing but is teeming with quantum particles that fluctuate between being and nothingness. These tiny particles can come into existence for a fraction of a second before they annihilate each other, leaving nothing behind. A vacuum in that sense is like the surface of an ocean. Up close it is churning with waves, but from a longer distance such as from a jet plane, it appears smooth and placid. Similarly, any vacuum examined close up with the proper instruments is seen to be churning with tiny particles." "Before the Big Bang," *Natural History*, 92 (April 1983), p. 26.

Tryon concluded: "If it is true that our Universe has a zero net value for all conserved quantities, then it may simply be a fluctuation of the vacuum, the vacuum of some larger space in which our Universe is imbedded. In answer to the question of why it happened, I offer the modest proposal that our Universe is simply one of those things which happens from time to time."⁴ Or, as Professor Alan Guth of MIT remarked in 1983: "It is often said that there is no such thing as a free lunch. The universe, however, is a free lunch."⁵ What is important for the subject of this paper is not so much the accuracy of the details of these particular claims, but rather, what appear to be the philosophical and theological implications of the new physics.

We live in the aftermath of a giant explosion, or perhaps it might be more accurate to say that we live in the midst of a giant explosion: an explosion which commenced between 15 and 20 billion years ago, and from which our universe has been expanding ever since. Scientists dispute whether the forces generated in that cosmic Big Bang are so powerful that the universe will continue to expand until it dies a cold and lonely death, or whether the amount of stuff in the universe is sufficiently large so that eventually gravitational attraction will succeed first in stopping the expansion and then in reducing the universe to a small, hot cosmic mass. The destiny of the universe seems to be either ice or fire!

Most physicists refer to the Big Bang as a "singularity," that is, an ultimate boundary or edge, a "state of infinite density" where spacetime has ceased. Thus, it represents an outer limit of what we can know about the universe. Since all physical theories are formulated in the context of space and time, it would not be possible to speculate, at least in the natural sciences, about conditions "before" or "beyond" these categories.⁶ But it is precisely such speculation which has intrigued some contemporary

The vacuum, according to quantum mechanics, is a system like any other system, and some cosmologists, arguing that every system will proceed toward a state of lowest possible energy, think that the energy in the universe at the moment of the Big Bang was less than the state before. In the words of Frank WILCZEK: "Perhaps the reason that there is something instead of nothing is that nothing is unstable." Quoted in James TREFIL, *The Moment of Creation* (New York: Macmillan, 1983), pp. 205-6.

4. *Nature*, Vol. 246, *op. cit.*, p. 397.

5. A. H. GUTH, "Speculations on the Origin of the Matter, Energy, and Entropy of the Universe," in *Asymptotic Realms of Physics: A Festschrift in Honor of Francis Low*, ed. by A. H. Guth, K. Huang, and R. L. Jaffe, (MIT Press, 1983), p. 215.

6. Paul DAVIES, *God and the New Physics* (New York: Simon and Schuster, 1983), pp. 18-19, p. 55. Steven WEINBERG in *The First Three Minutes* (New York: Basic Books, 1977) and James TREFIL in *The Moment of Creation*, *op. cit.* are quick to point out the highly speculative nature of all theories about the very early existence of the universe. Davies, however, does remark that "a singularity is the nearest thing that science has found to a supernatural agent." (pp. 55-56) And he also notes that "an example of a singularity is the infinitely dense, infinitely compact state that marked the beginning of the big bang." Davies would be advised to adopt what Roger Penrose and Stephen Hawking call the "principle of ignorance," that is, that "singularity is the ultimate unknowable, and therefore should be totally devoid of information." See: S. W. HAWKING, "Breakdown of a Predictability in Gravitational Collapse," *Physical Review D*, 14 (1976), p. 2460. Penrose and Hawking, using elaborate mathematical arguments, contend that when gravity is strong enough singularities are unavoidable. This is the source of the view that the universe comes from a mathematical point. DAVIES observes: "These bizarre ideas [with respect to 'singularity'] can only be fully grasped by appeal to mathematics." (p. 19) There seems to be some confusion here between a mathematical and a physical analysis of the universe. And, as we shall see, even Trefil, despite his cautions, uses terms such as "nothing" and "creation" with inadequate precision. See footnote 12.

cosmologists who have offered refinements in Tryon's original proposal concerning a physical explanation of the universe's emergence from nothing. In a 1983 article Professor Alexander Vilenkin of Tufts University argues for "a new version of the inflationary scenario in which the Universe is spontaneously created from *nothing* [his italics]." ⁷ Following on the work of Alan Guth — who is credited with the "inflationary model" of an expanding universe from a primal Big Bang — Vilenkin describes "the birth of the inflationary universe by quantum tunneling from nothing." ⁸ "Nothing," according to Vilenkin, is "a state with no classical space-time... the realm of unrestrained quantum gravity; it is a rather bizarre state in which all our basic notions of space, time, energy, entropy, etc., lose their meaning." ⁹

Vilenkin, Guth, and others base their variation in the Big Bang theory on extrapolations from high energy physics. Today physicists describe our universe in terms of four fundamental forces [the strong, the weak, gravity, and the electromagnetic] and twelve elementary sub-atomic particles [six leptons and six quarks]. ¹⁰ These forces and particles are, however, "low temperature phenomena." As a result of evidence from background micro-wave radiation, physicists estimate the present temperature of the universe to be 2.7 degrees Kelvin (and getting colder). At the temperatures estimated at the time of the Big Bang itself, that is, temperatures around 10^{32} degrees Kelvin, all the forces of nature existed in a single, undifferentiated superforce, and all the now disparate sub-atomic particles had yet not acquired distinct identities. A fundamental transformation occurred in our very young universe, long before it was even one second old: in fact when it was about 10^{-35} second old. The rapid "supercooling" of the universe, a universe at the time but the size of a softball, produced a tremendous amount of energy, some of which condensed into matter.

For those cosmologists unwilling to accept an unexplained Big Bang, or an explanation which seemed to them to require a supernatural agent, this new variation of the Big Bang theory is welcome. This new account of the very early history of the universe offers a resolution to what has been a troublesome problem for any one who proposed that the universe could emerge from some kind of cosmic nothingness. And this problem concerns the superabundance of matter to anti-matter in the universe. Laboratory experiments, ever since the discovery of the positron [i.e., the anti-electron] in 1932, seem to indicate that high energy collisions in particle accelerators produce equal quantities of particles and anti-particles. Yet, in our immediate world we almost never encounter anti-particles. If the entire universe contains an overwhelming preponderance of matter to anti-matter, was it always thus? If not, that is, if there were

7. *Physical Review D*, Vol. 27, No. 12, 15 June 1983, p. 2848.

8. *Ibid.*, p. 2849.

9. *Ibid.*, p. 2851.

10. Recently there has been speculation concerning a fifth fundamental force; see: *Physical Review Letters*, 6 January 1986.

an original equilibrium state, how did the present asymmetry come about? ¹¹ Tryon thought that he could explain that the universe “did... appear from nowhere” and that such an event “need not have violated any of the conventional laws of physics.” The “conventional laws of physics” in this instance are those which concern the conservation of mass and energy: laws which, seemingly, would be violated were we to affirm that the universe came from nothing. Objections to Tryon’s attempt to account for the spontaneous emergence of the universe from nowhere, while at the same time preserving the conservation laws, seemed irrefutable.

It is precisely here that the “inflationary universe” proposed by Guth and Vilenkin is so important: first there is a primal Big Bang, a “quantum tunneling from nothing,” and then, after a brief phase of “runaway exponential expansion,” the energy accumulated would at the termination of this phase become converted into matter and radiation, and the universe would then proceed to develop more or less as we have come to understand it. Paul Davies, the British physicist, who has written widely on recent discoveries in particle physics and their philosophical and theological implications, notes that the theory of the “inflationary universe” accounts for the emergence “out of nothingness” of both fundamental particles and spacetime itself “as the result of a causeless quantum transition.” ¹² And the theory is also consistent with

11. Antiparticles are discrete quantities which have the same magnitude but opposite charge from corresponding particles: e.g., anti-electrons, anti-neutrinos, and the like. See Frank WILCZEK, “The Cosmic Asymmetry between Matter and Antimatter,” in *Scientific American*, December 1980, Vol. 243, No. 6, pp. 82–90. Wilczek thinks that in the extremely dense, hot universe of the big bang there were equal amounts of matter and antimatter, but from 10^{-35} second after the big bang there has been more matter. (p. 82) A good summary of the problems of accounting for such an asymmetry — especially as it concerns perturbations in the very early history of the universe — can be found in M. S. LONGAIR, “The Universe — present, past, and future,” *Contemporary Physics*, 1986, Vol. 27, No. 4, pp. 325–43.

12. *God and the New Physics*, p. 215. When Davies speaks of a “causeless quantum transition,” he is using the term “cause” to refer to a temporal succession of predictable events. There is a great deal of confusion in the philosophical interpretation of quantum mechanics: especially with respect to the meaning of Heisenberg’s “relation of uncertainty.” It is one thing to affirm that we are not able to provide a precise mathematical measure of both the velocity and the position of a subatomic particle. It is quite another thing either to deny the objective reality of the particle or to contend that there is a realm of “causeless” effects. We might not be able to predict certain events; this does not mean that these events have no cause. For a well-argued analysis of this question, see Stanley JAKI, “Chance or Reality: Interaction in Nature Versus Measurement in Physics,” in *Yearbook of the Research Center for Greek Philosophy at the Academy of Athens*, Nos. 10–11, 1980–1981.

DEWITT observes, in the December 1983 article cited in footnote 5: “A quantized spacetime is one whose causal structure is fluctuating and uncertain. At Planckian dimensions the very distinction between past and future becomes blurred. By analogy with the phenomenon of tunneling in atomic systems, which allows an electron to pass through an energy barrier it cannot climb over, one must expect processes that are not allowed in Einstein’s classical theory, including faster-than-light travel over Planckian distances.” In the summary introduction to his article, DEWITT, noting that a gravitational field is a curvature of spacetime and that the quantum world “is never still,” remarks: “In a universe governed by quantum gravity the curvature of spacetime and even its structure would be subject to fluctuations. Indeed, it is possible that the sequence of events in the world and the meaning of past and future would be susceptible to change.” *art. cit.*, p. 126.

Planckian units are far removed from everyday physics. Planck’s unit of length is 1.61 times 10^{-35} centimeters: which is 21 powers of 10 smaller than the diameter of an atomic nucleus. His unit of time is 5.36 times 10^{-44} second. DeWitt reminds us that to probe time and distances of such scales, using instruments built with present technology, would require a particle accelerator the size of the galaxy. (p. 126)

the observed preponderance of matter to anti-matter. Davies summarizes the new theories in one of his recent books, *God and the New Physics* (1983):

In this remarkable scenario, the entire universe simply comes out of nowhere, completely in accordance with the laws of quantum physics, and creates along the way all the matter and energy needed to build the universe as we now see it.

And in a more grandiose vein, he remarks:

Some physicists, inspired by the simplicity of nature's fundamental laws, have argued that perhaps the ultimate law (in this case the superforce [produced in the Big Bang]) has a mathematical structure which is uniquely defined as the only logically consistent physical principle. That is to say, physics is proclaimed "necessary" in the same way that God is proclaimed necessary by theologians. Should we then conclude that God is physics? ¹³

Cosmological theories often appear to address topics that are also the subject of religious belief. The explanation of the origin of the universe is surely such a topic. Indeed, the doctrine of creation is one of the central concepts of the Western theological tradition, and in understanding what creation is theologians have used arguments based on the natural sciences. But the natural sciences have also served as a reservoir of ideas for those thinkers who denied the reality or intelligibility of creation from nothing.

And, in fact, these recent reflections in the new physics on the "state" of "things" "before" the Big Bang would seem to offer encouragement both to those who affirm the traditional Christian doctrine of "creation from nothing" as well as to those who see no need to appeal to God to explain the origin of the universe. The latter are reminiscent of Laplace who, when Napoleon asked him about the role of God in his cosmology, was alleged to have replied that he had no need for such a hypothesis. These new cosmological theories deny the existence even of a mechanistic God lurking "behind" the Big Bang: a God who pulls the trigger, so to speak, and brings the universe into existence through some giant explosion. As we have seen, Tryon himself observed that the laws of physics are fully adequate to account for the origin of our universe.

On the contrary, some believers who have been encouraged to embrace the Big Bang explanation of the origin of the universe as consistent with or as a confirmation

To investigate occurrences earlier than 10^{-43} second after the Big Bang cosmologists need to know the effects of quantum mechanics on the force of gravity. James TREFIL observes that if a quantum mechanical theory of gravitation were developed "we would be able to push our knowledge of the history of the early universe beyond the Planck time to the moment of creation itself. The first 10^{-43} second interval could be very interesting, involving physical processes never seen in the universe since that time." TREFIL does admit that the "ultimate origin of the universe" may be beyond the explanatory categories of physics. "Nevertheless, it does seem to be a bit disappointing to have come so far in our study of creation only to be brought up short on the verge of solving the most interesting problem of all... Although the creation of the universe may involve a process we have never seen (and never can see), let us assume that the laws of nature that we have discovered can be used to think about it." *The Moment of Creation*, pp. 197, 204, 205. Note that Trefil identifies "creation" as a "process," i.e., as a kind of change.

13. *Ibid.*, p. 216: "... the world of quantum physics routinely produces something for nothing."; and p. 55.

of Christian revelation¹⁴ may be further seduced into thinking that the “creation from nothing” to which Vilenkin and others refer adds scientific proof — or the possibility of scientific proof and, hence, a certain rational respectability — to one of the central tenets of Christianity. We need, however, to be very careful in evaluating the claims of any cosmological theory about the origin of the universe: whether we think we find in it evidence for the affirmation, or for the denial, of the existence of God. On the one hand there is the danger of a false notion of the incompatibility between religion and science; and on the other hand there is the danger of a simplistic misunderstanding of the complementarity between religion and science. The discussion of these and related questions is pervaded by equivocations and faulty logic, and it occurs in the midst of

14. The second law of thermodynamics affirms the irreversibility of cosmic processes and thus suggests a direction to all transformations in the universe. The discovery of change in the deepest recesses of the subatomic world offers further evidence for the existence of an immutable God: the argument proceeds from the fact of mutability in things to the necessity of an immutable Being.

Pope Pius XII, in 1951, in an address to the Pontifical Academy of Sciences commented on what he considered to be the convergence between modern science and Christian theology: “... with the expanding and deepening of the field of human experiments, the vestiges of the Eternal One are discernible in the visible world in ever more striking and clearer light.” The Pope indicated that the ultimate origin of the matter of the universe is outside the domain of the natural sciences. Nevertheless, he added:

“It is undeniable that when a mind enlightened and enriched with modern scientific knowledge weighs this problem [the ultimate origin of matter] calmly, it feels drawn to break through the circle of completely independent or autochthonous matter, whether uncreated or self-created, and to assent to a creating Spirit. With the same clear and critical look with which it examines and passes judgment on facts, it perceives and recognizes the work of creative omnipotence, whose power, set in motion by the mighty ‘Fiat’ pronounced billions of years ago by the Creating Spirit, spread out over the universe, calling into existence with a gesture of generous love matter bursting with energy. In fact, it would seem that present-day science, with one sweeping step back across millions of centuries, has succeeded in bearing witness to that primordial ‘Fiat lux’...”

“The farther back we go [in time], the more matter presents itself as always more enriched with free energy, and as a theater of vast cosmic disturbances. Thus everything seems to indicate that the material universe had in finite times a mighty beginning, provided as it was with an indescribably vast abundance of energy reserves, in virtue of which, at first rapidly and then with increasing slowness, it evolved into its present state.”

Sir Edmund WHITTAKER, whom the Pope quoted approvingly, wrote: “These different calculations [of modern cosmology] point to the conclusion that there was a time, some nine or ten billion years ago, prior to which the cosmos, if it existed, existed in a form totally different from anything we know, and this form constitutes the very last limit of science. We refer to it perhaps not improperly as creation. It provides a unifying background, suggested by geological evidence, for that explanation of the world according to which every organism on earth had a beginning in time. Were the conclusion to be confirmed by future research, it might well be considered as the most outstanding discovery of our times, since it represents a fundamental change in the scientific conception of the universe, similar to the one brought about four centuries ago by Copernicus.” (*Space and Spirit* [1946], pp. 118-119)

The quotations above are found in: *The Major Addresses of Pope Pius XII*, Vol. 1, edited by Vincent A. Yzermans. (St. Paul: The North Central Publishing Company, 1961), pp. 178, 186-187, 188.

It is fascinating to note the reaction of Soviet scientists in the 1950's and 1960's to cosmological discussions. V. I. SVIDERSKI, in 1956, rejected both the Big Bang and the steady state theories, and noted that the former was an “unscientific popish conclusion.” One of the leading Soviet astrophysicists, V. A. AMBARTSUMIAN, declared in 1959 that the advances of science “irrefutably attest to the truth and fruitfulness of dialectical materialism” as well as “convincingly demonstrating the complete unsoundness of idealism and agnosticism, and the reactionariness of the religious world-view.” Quoted in: Ernan McMULLIN, “How Should Cosmology Relate to Theology?” in *The Sciences and Theology in the Twentieth Century*, edited by A. R. Peacocke, (London: Oriel, 1981), pp. 36-37. See also, Loren GRAHAM, *Science and Philosophy in the Soviet Union* (New York, 1972).

generally accepted, but defective, views concerning the relation between religion and science, faith and reason.

It is commonplace today to refer to two broad categories of explanation concerning the origin of the universe. The first is that the Bible, and especially Genesis, contains an adequate explanation of the origin of the universe. In its most extreme form, this view is that in Genesis there is a straightforward account of God's creation of everything in the universe, including man. Genesis, thus, offers a sufficient account not only of the fact of creation, but also the order, mode, and details of creation. Since the Bible is the unerring word of God, this text must be treated as an infallible guide on all subjects which it addresses.

The second view is that the modern natural sciences provide the only rational description of the origin and nature of the universe. Physics, geology, biology, paleontology, anthropology, astronomy, and the like account for the various changes which have produced the cosmos as we know it. Indeed, for some, science demonstrates, or perhaps requires, that the universe be eternal, that is, that it cannot have a beginning in time. In its most extreme form, the view which finds in the natural sciences the only acceptable avenue to knowledge about man and his world maintains that there is a fundamental continuum from matter and energy to man, and, further, that the "laws of nature" — whether we know them all or not — are sufficient to answer all our questions about the universe and its origins. Thus, we can see the attractiveness of the cosmological thesis of "quantum tunneling from nothing" as a supposedly rational, scientific account of the Big Bang itself.

Both general views ought to be rejected: both are caricatures. One is creationism, the other is scientism. These so-called "religious" and "scientific" explanations of the origin of the universe embody misunderstandings of religion and science, and they tend to confuse, as well, not only the different senses of "origin" and of "nothing," but also the distinctions between creation and change. The confusion usually entails the presupposition that there has been and is a necessary hostility between a religious and a scientific view of the world, an incompatibility between faith and reason.¹⁵ The confusion in discussions concerning the theological implications of the new physics is evident in the work of Paul Davies. In the preface to *God and the New Physics* he observes that modern physics is:

... pointing the way to a new appreciation of man and his place in the universe.
Deep questions of existence — How did the universe begin and how will it end?

15. The modern *locus classicus* of this view is *A History of the Warfare of Science with Theology in Christendom* (1896) by Andrew DICKSON WHITE. In the first chapter, entitled "From Creation to Evolution," WHITE writes: "Thus down to a period almost within living memory, it was held, virtually, 'always and everywhere, and by all,' that the universe, as we now see it, was created literally and directly by the voice or hands of the Almighty, or by both — out of nothing — in an instant or in six days, or in both — about four thousand years before the Christian era — and for the convenience of the dwellers upon the earth, which was at the base and foundation of the whole structure." (pp. 13-14, Dover Paperbacks, 1960) When Newton "had shown throughout the universe, in place of almighty caprice, all-pervading law," he provided the foundation, according to White, for the theory of evolution to replace the doctrine of creation.

For a useful corrective to views such as those put forward by White, see E. McMULLIN, *art. cit.*, as well as A. R. PEACOCKE, *Creation and the World of Science*, (Oxford: Clarendon Press, 1979).

What is matter? What is life? What is mind? — are not new. What is new is that we may at last be on the verge of answering them. This astonishing prospect stems from some spectacular recent advances in physical science — not only the new physics, but its close relative, the new cosmology.

For the first time, a unified description of all creation could be within our grasp. No scientific problem is more fundamental or more daunting than the puzzle of how the universe came into being. Could this have happened without any supernatural input? Quantum physics seems to provide a loophole to the age-old assumption that “you can’t get something from nothing.” Physicists are now talking about the “self-creating universe”: a cosmos that erupts into existence spontaneously, much as a subnuclear particle sometimes pops out of nowhere in certain high energy processes. The question of whether the details of this theory are right or wrong is not so very important. What matters is that it is now possible to conceive of a scientific explanation for all of creation. Has modern physics abolished God altogether...?

... I believe that physics is uniquely placed to provide [answers to “the deep questions of existence”]. It may seem bizarre, but in my opinion science offers a surer path to God than religion. Right or wrong, the fact that science has actually advanced to the point where what were formerly religious questions can be seriously tackled, itself indicates the far-reaching consequences of the new physics.¹⁶

Is such an appeal to the explanatory power of physics convincing? In fact, must not the laws or principles of physics exist, in some sense, in order for them to provide the basis of a “scientific explanation of all of creation”? We must remember that “laws of physics” are descriptive statements of what occurs in nature; in themselves they are not the causes of what occurs. Thus, if such laws exist prior to the Big Bang, then it would seem that either there is some physical reality from which the universe came to be, or these laws exist in the mind of God. In the first case, the explanation would not be of the universe’s coming-into-being from nothing; in the second, we must appeal to a creating God.¹⁷

An examination of some of the scientific and theological questions concerning cosmology and creation will enable us to discover the appropriate roles of reason and faith in discussing the origin of the universe, and, in the process, to begin to disentangle the web of confusion, terminological and conceptual, which surrounds this subject.

What is an origin or a beginning? We need to note at the outset the relative nature of these terms. An origin is a “from which,” i.e., an origin necessarily entails something which follows: the beginning of a line, of a journey, of a story, and so forth. An origin or a beginning is a first, and there are two different senses of what it means to be first: a qualified sense and an unqualified sense. In order to have an origin in a qualified sense

16. DAVIES, *op. cit.*, pp. vii, viii, and ix.

17. I should like to thank the reviewer of articles for this journal for encouraging me to make this point explicit. For a recent discussion of some of the deficiencies in Davies’ arguments, see William LANE CRAIG, “God, Creation and Mr Davies,” in *British Journal for the Philosophy of Science*, Vol. 37 (1986), pp. 163–175, especially p. 168.

some change has occurred in some thing which has resulted in a new thing or a new situation having come into existence: a pile of wood as the origin of a desk; an acorn as the origin of an oak tree; paint, canvas, and artist as the different origins of a painting. An origin in an unqualified sense means a first absolutely, that is, a first which in no way involves a change in some thing. If it were a change which brought the new reality into existence then the origin of the new reality would be a first only in a qualified sense, since there would have been some prior thing which underwent the change. And the existence of the prior something which underwent the change would deny to the origin of the new reality the status of being unqualifiedly first. An unqualified origin does not rule out an agent as the source, in some fundamental sense, of what comes to be, but it does exclude any other preexistent reality as an origin.

When we ask about the "origin of the universe" we may wish to inquire about a beginning in a qualified sense or in an unqualified sense. We must be very careful not to confuse these two quite different senses of origin. The natural sciences study changing things, and thus they only consider the qualified sense of origin. It is not possible to get something from nothing: this is a fundamental principle of all of the natural sciences. Today we often refer to this principle in a more particular form: the conservation of mass/energy. Every origin in a qualified sense involves a change, and every change requires that there be some thing or condition which changes. Modern cosmological theories, such as the Big Bang theory, are explanations of the origin of the universe only in a qualified sense. Whether we accept or reject the notion of the Big Bang, it is an explanation of a change. When Tryon, Vilenkin, Davies, and others speak of "creation from nothing" they are using the words "creation" and "nothing" in very loose senses. Vilenkin, himself, admits: "by nothing I mean a state with no classical space-time."¹⁸ This "bizarre state", as Vilenkin calls "nothing," is really something! There are different senses of "nothing," and Vilenkin is using one of them, viz., a qualified sense. A "state with no classical space-time" may be nothing like the universe of classical space-time, but this pre-Big Bang "state" is not absolutely nothing. This qualified sense of "nothing" is not the sense of "nothing" which is central to the Christian theological notion of "creation from nothing", in which "nothing" is taken in an absolute or unqualified sense.

Creation, as a proper theological concept, refers to the origin of the universe in the absolute or unqualified senses of origin and of nothing. Such an origin is not, indeed, cannot involve, a change: otherwise we would be referring to a qualified and not to an unqualified origin. Can we investigate the origin of the universe in this unqualified sense? What are the sources of information? Indeed, is it intelligible to speak of an unqualified origin of all that is?

First let us consider the role of reason in such an investigation. The natural sciences, as we have said, have as their subject changing things. Thus they do not address directly the unqualified origin of all that is. Some thinkers, ancient as well as contemporary — the most famous among them, Aristotle — concluded that the universe is eternal, that is, without a beginning in time. A consideration of the reality

18. *Physical Review D*, *op. cit.*, p. 2851.

of change and of time led Aristotle, for example, to argue that there must always be change and time.¹⁹ Such a view seems to contradict the very notion of creation. And in the 13th century scholars of the calibre of Albert the Great, Bonaventure, and Thomas Aquinas labored mightily over the arguments of Aristotle and what they portended for the Christian belief in creation and especially creation in time. The questions in the debate over the eternity of the universe are complex, but even if we were to grant that in fact the universe is eternal this would not involve a denial of creation.²⁰ In other words, there could be an eternal, created universe. Such was the conclusion of Thomas Aquinas, and we owe to him, more than to any other, the most profound analysis of the Christian understanding of creation.

To see how Aquinas could argue that the universe could be without a beginning in time and yet be created, we need to examine in more detail what an unqualified origin is. And in this investigation we enter the realm of metaphysics, the rational study of what it means for things "to be." Notice that we are considering what we can know through reason alone. And if we recognize the legitimacy of the science of metaphysics, we must deny that *only* the natural sciences can provide a rational account of reality. Consider a spoon. It exists; it "be's." What is the cause of its existence, of its being? What it means to be a spoon does not include existence: spoons do not have to exist. To exist is not part of what it means to be a spoon; existence is not part of the definition of a spoon. Clearly the cause of the existence of any spoon, viz., that which is responsible for the effect which is existence, is not in the spoon. The spoon is not self-caused. In some sense, those who made the spoon are causes of its existence. But as the spoon exists, after it has been produced, the continuing effect which is its existence does not depend directly upon those who made the spoon. Yet the spoon continues to exist. Existence is an effect and thus must have a cause. The spoon may undergo several changes, including that change which involves its ceasing to be a spoon. But whatever the change is, the existence of that which results is itself, in turn, caused to be in an unqualified sense, that is, it is created. What is true of the spoon is true of the universe as a whole. And creation, understood philosophically, that is, understood in the science of metaphysics, is the radical causing of the whole being of whatever is. Such an unqualified causing or coming-to-be may or may not have a beginning in time: that is, there is no mutual repugnance in the ideas of what it means to be created and what it means to have no beginning in time. Left exclusively to itself, that is, separated from the cause of being, any thing is absolutely nothing. To use the terms of metaphysics: creation is the primary, unqualified, efficient causing of the being of everything which exists. Creation is not simply some distant event: it is the on-going causing of all that is. And we arrive at this understanding of creation through the rational reflection on what it means "to be."

19. *Physics* VIII: 251a8-252a3.

20. See C. VOLLERT, *et al.*, (eds.), *On the Eternity of the World* [Aquinas, Siger of Brabant, and Bonaventure] (Marquette University Press, 1964). AQUINAS argues that Aristotle in his *Physics* has a demonstration of creation, that is, of the simultaneous causing of the existence of all contingent beings. Thus, for Aquinas, the God of Aristotle is not only a cause of motion, but also a cause of being (*causa essendi*). See: AQUINAS, *In VIII Phys.*, lectio 2. We need to remember, however, that Aristotelian physics is a more comprehensive science of nature than the modern natural sciences.

Even if we were to deny the accuracy of the metaphysical arguments for creation, or if we were to deny the very existence of metaphysics, we would still be left with the silence of the modern natural sciences concerning the unqualified origin of the universe. And if faith speaks in the midst of the silence of reason, there is, at least in this instance, no hostility between the two. The fundamental error in most discussions about creation and the natural sciences is to consider creation as a kind of change. Evolution, whether cosmic or biological, is an explanation of change and is a concern, thus, of the natural sciences. Creation explains the existence of things; it does not explain how natural processes function, no matter how large or ancient these processes are. No theory in the natural sciences can contradict the doctrine of creation, since what creation accounts for is not a process at all, but a metaphysical dependence in the order of being.²¹

What is the role of faith in disclosing the unqualified origin of the universe? Here we must refer both to Sacred Scripture and to theology. Genesis does speak of the origin of the universe, but not in a scientific way. The Bible is not a source of scientific information. It is not written to explain nature, but, rather, to reveal the proper relation between man and God so that men may be led to salvation. The Bible is an account of religious and moral truths; it is not an account of truths in the natural sciences. As Cardinal Baronius noted in the sixteenth century: the Bible teaches us how to go to heaven, not how the heavens go. Those scientific arguments or theories found in the Bible are secondary material used to convey religious and moral truths.²² These truths are enveloped in language and manifested in examples in such a way that they are accommodated to human understanding. Great theologians, such as Augustine in the 4th century and Aquinas in the 13th century, were well aware that the proper way to read Scripture included distinguishing between the essential message of the Bible and the ways in which this message is made accessible to men. As Augustine pointedly noted: "One does not read in the Gospel that the Lord said: I will send to you the Holy Spirit who will teach you about the course of the sun and the moon. For He willed to make them Christians, not mathematicians."²³

The opening line of Genesis, "In the beginning, God created the heavens and the earth," is not easy to interpret. What does "in the beginning" mean? Although the traditional interpretations take these words to mean that there was a beginning of time,²⁴ Augustine and Aquinas recognized additional legitimate ways to explain the text. Aquinas, in particular, affirming that "in the beginning" does mean that the universe is not eternal, argued that the opening phrase of Genesis can have meanings in addition to that of a temporal beginning. The Latin, *in principio*, and the Greek, *en*

21. I should like to acknowledge the insights into the distinctions between creation and change which I have received from Dr. Steven Baldner of St. Thomas More College, University of Saskatchewan.

22. For the distinction between primary and secondary material in Scripture, see AQUINAS, *Summa Theologiae* II-II, q. 2, aa. 5-6.

23. AUGUSTINE, *De actis cum Felice Manicheo*, I, 10: quoted in Jerome LANGFORD, *Galileo, Science, and the Church* (Ann Arbor, 1971), p. 65.

24. AUGUSTINE, *De Genesi ad litteram* IV, 34, 53-55; *De civ. Dei* IX, 4; and AQUINAS, *Summa Theologiae* I, q. 46, a. 2.

arche may be rendered as “in the cause”, or “in the source,” or “in the principle.” The first line of Genesis may mean, thus, that God created all things in, or through, the principle, or cause, or source of all things. If we take the first three verses of the Gospel of John [“In the beginning was the Word...”] as a parallel text, then we may understand that “in the beginning” in Genesis means that God the Father creates the universe in and through God the Son.²⁵

Augustine, analyzing the hexameral account in Genesis, was convinced that creation did not take place over six days. God’s creative act was instantaneous, and the story of the six days reveals analytical distinctions in creation, not a temporal succession.²⁶ Thomas Aquinas, referring to the debate in which Augustine was involved concerning the opening of Genesis, remarks:

There are some things that are by their very nature the substance of faith, as to say of God that He is three and one, and other similar things, about which it is forbidden for anyone to think otherwise... There are other things that relate to the faith only incidentally... and, with respect to these, Christian authors have different opinions, interpreting the Sacred Scripture in various ways. Thus with respect to the origin of the world, there is one point that is of the substance of faith [*ad substantiam fidei pertinet*], viz., to know that it began by creation [*incepisse creatum*], on which all the authors in question are in agreement. But the manner and the order according to which creation took place concerns the faith only incidentally, in so far as it has been recorded in Scripture, and of these things the aforementioned authors, safeguarding the truth by their various interpretations have reported different things.²⁷

Elsewhere Aquinas observes:

In discussing questions of this kind [the manner and mode of creation as set forth in Genesis] two rules are to be observed as Augustine teaches (*De gen. ad litt.*, I, 37). The first is to hold to the truth of Scripture without wavering. The second is that since Holy Scripture can be explained in a multiplicity of senses, one should adhere to a particular explanation, only in such measure as to be ready to abandon it, if it be proved with certainty to be false; lest Holy Scripture be exposed to the ridicule of unbelievers, and obstacles be placed to their believing.²⁸

Furthermore, when Augustine and Aquinas speak of the unerring literal sense of Scripture they are not adhering to what we today would call a “literal” or a “fundamentalist” interpretation of the text. The literal sense for Aquinas is what the words signify, but the modes of signification are varied, and one must know how to read the text. God is the principal author of Scripture and the literal sense is what God intends the words to signify: an intention which might not be known by the human

25. *In II Sent.* 1, 1, 6; *Summa Theologiae* I, q. 46, a. 3; and AUGUSTINE, *De Genesi ad litt.*, I, 5, 10; I, 6, 12. I am indebted to Professor Baldner for pointing out to me these references, and those in footnote 24.

26. Augustine thought that in the initial act of creation God produced the seeds, the *rationes seminales*, of all that has come and will come to be.

27. *In II Sent.* 12, 1, 2.

28. *Summa Theologiae* I, q. 68, a. 1.

author of the text.²⁹ Since the literal sense involves what God intends, it can only be made fully clear in faith and through the Church. Aquinas might very well agree with the clarion call: *sola scriptura*! But he would be quick to note that there is no *Scriptura* without the *Ecclesia*. What we may term "literalistic" readings of Genesis which are often characteristic of "creationist" accounts of the origin of the universe often involve a too hasty commitment to a particular interpretation of the biblical text. Or, what is far worse, they may involve a failure to understand the distinction between the primary purpose of the Bible and the manner in which moral and religious truths are accommodated to human understanding. Thus, such interpreters in their zeal to affirm the Bible as the unerring word of God enshrine, as infallible truths, notions which are not in fact signified by the words of the sacred text. As Augustine notes, if scientific knowledge precludes what is proposed as an interpretation of a particular text of Scripture, then this proposed teaching "was never in Holy Scripture but was an opinion proposed by man in his ignorance."³⁰

Theologians such as Aquinas, reflecting on revelation and the Church's understanding of it, developed an elaborate analysis of "creation out of nothing" [*creatio ex nihilo*]. Creation is not God's taking nothing and making something out of "it." In other words, creation is not a change; it is not a *mutatio*. In faith, the Christian confesses that everything comes from God. If creation were a change, if God were to work with some primal, uncreated stuff, then for a Christian to accept such a view of creation would mean a denial of his confession that God is the sole source of all that is. Nor is creation to be seen as a kind of emanation, or "bubbling over," of all that is from God [*de Deo*]. The Christian believes in a transcendent God, and there must be a fundamental distinction between Creator and every creature. Every creature is radically contingent, that is, is radically dependent for its very being upon God's free creative act. Creation is wholly gratuitous; it is completely an act of God's mercy. Without His causality no thing could be. In an analysis similar to that of the metaphysician, the theologian affirms that all things left wholly to themselves, thus separated from God as Creator, would be nothing. The expression "creation *ex nihilo*" captures the truly contingent nature of creatures. The notion of "nothing" here is theological and metaphysical: it is "nothing" in an unqualified sense, and thus it is not a concept applicable to the modern natural sciences.³¹

29. In particular, see *Summa Theologiae* I, q. 1, a. 10.

30. *De Gen. ad litt.* I, 38.

31. In a magisterial passage from the commentary on the *Sentences* of Peter Lombard, Aquinas sets forth his position on creation. Although it is an early work, Aquinas remains faithful throughout his career to the principles he enunciates in this text: 1) that creation is known through reason and through faith; 2) that creation is not a change and thus "presupposes nothing" in that which is created; and 3) that the universe has a beginning in time is an addition to the notion of creation which can only be known through faith. The passage follows:

"Not only does faith hold that there is creation, but reason also demonstrates it. For it is the case that everything which is imperfect in some genus, arises from that in which the nature of the genus is found first and perfectly, as is clear with heat in things hot by fire. Since, however, any thing whatever, and whatever is in the thing, in some way partakes being and is admixed of imperfection, it must be that every thing, in its entirety, arises from the first and perfect being. But we say that this is to create, namely to produce a thing in being according to its whole substance. Hence it is necessary that all things proceed from the first principle by way of creation.

Following the teaching of the Fourth Lateran Council [1215],³² medieval Catholic theologians affirmed that creation has a beginning in time, that is, the universe is not eternal. Aquinas, in refuting Aristotle's arguments for the eternity of the world, argued that the natural sciences cannot demonstrate that the universe is eternal. Reason alone, he thought, remains at least open to whether or not the universe has a beginning in time.³³ Thus, on the basis of faith, to believe in a temporal creation does not entail a conflict between the claims of faith and the claims of science.

The Christian believes that God is the author of all truth. Accordingly, the truths of science and the truths of faith cannot contradict one another. In the words of the First Vatican Council [1870]: "... there can never be any real discrepancy between faith and reason, since the same God who reveals mysteries and infuses faith has bestowed the light of reason on the human mind, and God cannot deny Himself, nor can truth ever contradict truth."³⁴ Apparent contradictions must be the result of defects in one's theology or in one's science, or in both. In this respect we may note how a confusion of categories concerning the different senses of origin and of nothing leads to false conclusions concerning the hostility between religion and science. We

Now it should be shown that two points pertain to the notion of creation. 1) The first is that it presupposes nothing in the thing that is said to be created. In this regard creation differs from other changes because: a) generation presupposes a matter which is not generated but (rather) is completed through the generation, being transformed into the act of a form, whereas b) in the remaining [kinds of] change there is presupposed a subject which is a complete being. Hence in this way the causality of that which generates or alters does not extend to all that is found in a thing but (only) to the form which is brought from potency to act. But the causality of that which creates extends to all that is in the thing. Thus creation is said to be *ex nihilo* [out of nothing], because there is nothing that preexists creation as something not created.

2) The second is that in the thing which is said to be created, the state of not-being is prior to the state of being — not indeed by a priority of time or duration so as first not to have been and then later to be, but by a priority of nature such that, if the created thing were left to itself, the state of not-being would result since the thing has being only by way of a higher cause's pouring it in [*ex influentia causae superioris*]. For each and every thing, prior to what it does have from another, naturally contains what it does not have from another. It is by reason of this second point that creation differs from eternal generation: for in this way it cannot be said that, if the Son of God be left to Himself, He would not have being, since He receives from the Father that very same being which is the Father's, which is absolute being, not dependent on anything.

According to these two points creation can be said to be *ex nihilo* in two ways: 1) in such a way that the negation [in the *nihilo*] denies the relatedness of creation to something pre-existent implied by the preposition "ex," so that creation may be said to be *ex nihilo* because it is not out of anything pre-existent. So much for the first point. 2) In pre-existent nothing according to nature, so that creation can be said to be *ex nihilo* because the created thing naturally has the condition of not-being prior to that of being. If these two points suffice for the notion of creation, then creation can be demonstrated; and it is in this way that philosophers have posited creation. 3) If, however, we regard a third created thing to be said to be *ex nihilo* it must have the condition of not-being prior to that of being even according to duration since it is temporally after nothingness, then creation cannot be demonstrated; nor is it conceded by philosophers but is supposed on faith."

[*In II Sent.* 1, q. 1, a. 2]

32. "We firmly believe and simply confess that there is only one true God... one origin of all things [*unum universorum principium*]; Creator of all things, visible and invisible, spiritual and corporeal; who by his own omnipotent power from the beginning of time created [*ab initio condidit de nihilo*] in the same way both orders of creation, spiritual and corporeal, that is, the angelic and the earthly..." Fourth Lateran Council, c. 1.

33. *In II Sent.*, q. 1, a. 5; and *De aeternitate mundi*.

34. *Constitutio dogmatica de fide catholica*, c. 4.

need to be aware as well of claims of a false complementarity based also on confusions over origin, nothing, creation, and change. Augustine's words on this subject have a clarity and a force unchanged from the time they were written more than 1 500 years ago :

Usually, even a non-Christian knows something about the earth, the heavens, and the other elements of this world, about the motion and orbit of the stars and even their size and relative positions, about the predictable eclipses of the sun and moon, the cycles of the years and the seasons, about the kinds of animals, shrubs, stones, and so forth, and this knowledge he holds to as being certain from reason and experience. Now, it is a disgraceful and dangerous thing for an infidel to hear a Christian, presumably giving the meaning of Holy Scripture, talking nonsense on these topics ; and we should take all means to prevent such an embarrassing situation, in which people show up vast ignorance in a Christian and laugh it to scorn. The shame is not so much that an ignorant individual is derided, but that people outside the household of the faith think our sacred writers held such opinions, and, to the great loss of those for whose salvation we toil, the writers of our Scripture are criticized and rejected as unlearned men. If they find a Christian mistaken in a field which they themselves know well and hear him maintaining his foolish opinions about our books, how are they going to believe those books in matters concerning the resurrection of the dead, the hope of eternal life, and the kingdom of heaven, when they think their pages are full of falsehoods on facts which they themselves have learnt from experience and the light of reason? Reckless and incompetent expounders of Holy Scripture bring untold trouble and sorrow on their wiser brethren when they are caught in one of their mischievous false opinions and are taken to task by those who are not bound by the authority of our sacred books. For then, to defend their utterly foolish and obviously untrue statements, they will try to call upon Holy Scripture for proof and even recite from memory many passages which they think support their position, although "they understand neither what they say nor the things about which they make assertion." (I Tim. 1 : 7)³⁵

The Bible does not address directly the question of the truth or falsity of any cosmological or evolutionary theory. Certain assertions in cosmology, biology, or any science may contradict the truths of faith. If these theories do in fact contradict the truths of faith, then the believer ought to reject them. Scientific theories which deny a qualitative distinction between non-human and human life, or which advocate an exclusively materialistic and deterministic account of reality are examples of views which are incompatible with Christian revelation. Of course, a Christian would have to affirm that any scientific assertion which does indeed contradict the truths of faith cannot possibly be true, and thus the inadequacy or falsity of such an assertion would be demonstrable on scientific grounds. We need to be cautious, however, in making judgments in this area: for we must understand both the scientific theory and the content of revelation. And, further, we need to remember that the Bible is not a text book in the natural sciences. Although Scripture may use arguments which draw upon scientific material, the apparent truth or falsity of the scientific statements in such arguments is irrelevant to the religious and moral truths proclaimed in Scripture.

35. *De Gen. ad litt.* 1, 39.

Some popularizers of science, or some scientists themselves, may make exorbitant claims for what the modern natural sciences can tell us about the origin of the universe : such exorbitant claims are just that, and they can be shown to be exorbitant on the basis of reason alone. Our universe may be expanding from a primal Big Bang, but “primal” must be understood as a qualified sense of first. The Big Bang may be the “fluctuation of a vacuum,” but it ought not to be confused with “creation from nothing.” Such a vacuum is, at best, nothing in a qualified sense ; it is not absolutely nothing. Fluctuation is a change ; it is not creation. The mechanistic God of some seventeenth and eighteenth century philosophers may well be eliminated by recent cosmological theories,³⁶ but not the Christian God who is the creator, *ex nihilo*, of the universe.

36. PASCAL's criticism of Descartes reminds us of such a mechanistic God : “Je ne puis pardonner à Descartes : il aurait bien voulu, dans toute sa philosophie, pouvoir se passer de Dieu ; mais il n'a pu s'empêcher de lui faire donner une chiquenaude pour mettre le monde en mouvement ; après cela, il n'a plus que faire de Dieu.” *Pensée* (L. Lafuma, ed.), 1001, (Paris : Éditions du Luxembourg), p. 553.